Pattern Reconfigurable using Half-wave Dipole Antenna

Nur Farahwahida Ab Aziz and R.Nilavalan
College of Engineering, Design & Physical Science,
Brunel University, London, UK.
Email: Nur.AbAziz@brunel.ac.uk

***Abstract* – A reconfigurable radiation pattern antenna is constructed using half-wave dipole antenna. Metal cylinders with pin diodes are added around the dipole antenna acted as reflector and cause the change in radiation pattern for particular direction. The reconfigurable antenna works up to 32 directions with minimum beam separation of 10°.**

Keywords— dipole antenna; pattern reconfigurable antenna.

I. INTRODUCTION

The vertical half-wave dipole antenna has a desired radiation pattern which can play an important role in addressing the issue of limited bandwidth[1]. The half-wave dipole antenna radiates equal power in all azimuthal directions perpendicular to the axis of the antenna[2][3]. The omnidirectional radiation pattern allows the vertical dipole antenna to broadcast and receive the signals from almost all directions.

II. ANTENNA DESIGN AND OPERATION

The principle of the proposed antenna is shown in Fig. 1a. Metal cylinders are placed around the half-wave dipole antenna and each metal cylinder is controlled by using pin diodes to determine the shape of radiation pattern of the reconfigurable antenna. The proposed antenna is constructed in HFSS as shown in Fig. 1b and the succeeding results is analyzed.

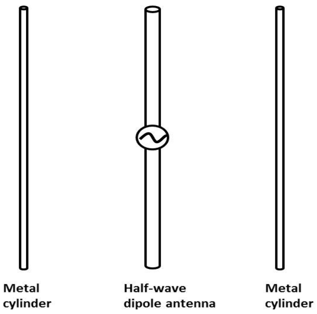


Fig. 1a.

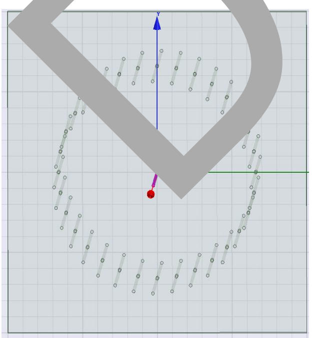


Fig. 1b.

The length of the metal cylinders is tested to find the maximum gain as well as determining the best bandwidth the antenna can offer. Fig. 2 shows the result of different length of metal cylinder tested starting from 61.5 mm to 77.0 mm with the corresponding gain and bandwidth from the antenna. Based on the graph, the antenna obtained maximum gain when the length of metal cylinder is 68 mm. However, the length of the metal cylinder is chosen to be 71.4 mm as it gives better bandwidth with reasonable gain. Other components of the antenna are also verified to find the most favorable dimension. Each metal cylinder has a radius of 0.5 mm to give maximum gain and the metal cylinders are situated 33 mm away from the dipole antenna.

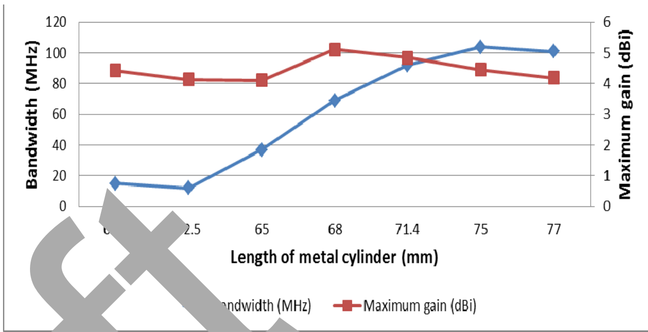


Fig. 2. Different length of metal cylinders with corresponding gain and bandwidth

The radiation pattern configurability of the dipole antenna is caused by manipulation of the length of metal cylinder placed around the dipole antenna. Pin diodes are used as switch to control the length of metal cylinders. When the switch is activated, the metal cylinder will have a total length of $\lambda/2$. The radiation pattern of half-wave dipole antenna reflected depending on which metal cylinder is turned on. The bandwidth of the antenna is improved accordingly with the appropriate length of metal cylinders.

TABLE I. DIFFERENT CASE OF PATTERN RECONFIGURABLE ANTENNA STUDIED

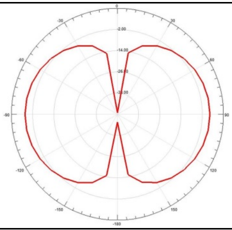
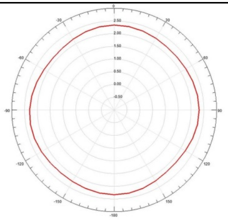
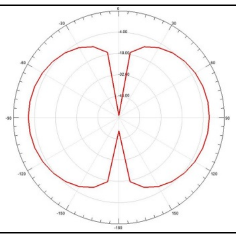
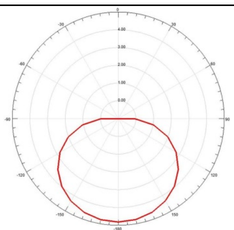
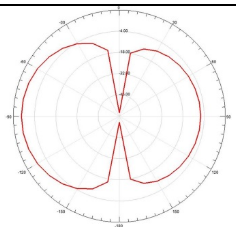
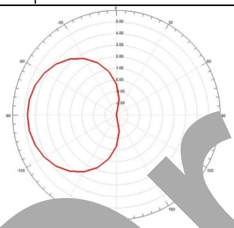
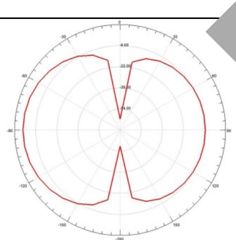
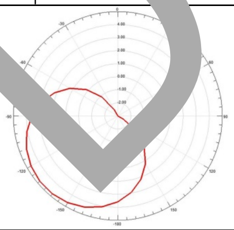
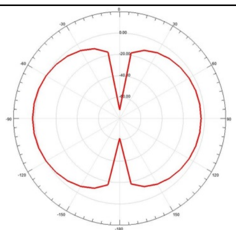
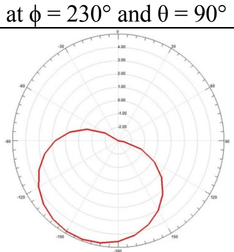
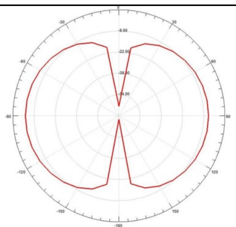
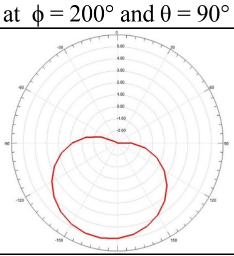
Case	Expected beam direction	Actual beam direction	Reconfigurable direction
Case A	360°	360°	All direction
Case B	180°	180°	2
Case C	270°	270°	4
Case D	225°	220°	8
Case E	202.5°	200°	16
Case F	191.25°	190°	32

Table I shows the expected main beam direction when the metal cylinder in that specific direction is activated. The exact value of maximum gain with radiation pattern at 1.06 GHz for the specific direction as each case studied is shown in Table II. However, there is a direction error occurs in Case D, E and F, as more metal cylinders are attached around the dipole antenna.

III. Result and Discussion

The simulated result shows that the proposed antenna provides maximum gain in different direction depending on which metal cylinder is switched on. The results show the radiation pattern at 1.06 GHz when the metal cylinder is activated with specific beam angle respectively.

TABLE II. Beam direction for different cases studied

Case A	 ϕ = 90° and θ = 0°	 Maximum gain:2.34 dBi at ϕ=All direction and θ=90°
Case B	 ϕ = 90° and θ = 0°	 Maximum gain: 4.839 dBi at ϕ = 180° and θ = 90°
Case C	 ϕ = 90° and θ = 0°	 Maximum gain: 4.727 dBi at ϕ = 270° and θ = 90°
Case D	 ϕ = 90° and θ = 0°	 Maximum gain: 4.822 dBi at ϕ = 230° and θ = 90°
Case E	 ϕ = 90° and θ = 0°	 Maximum gain: 4.923 dBi at ϕ = 200° and θ = 90°
Case F	 ϕ = 90° and θ = 0°	 Maximum gain: 4.994 dBi at ϕ = 190° and θ = 90°

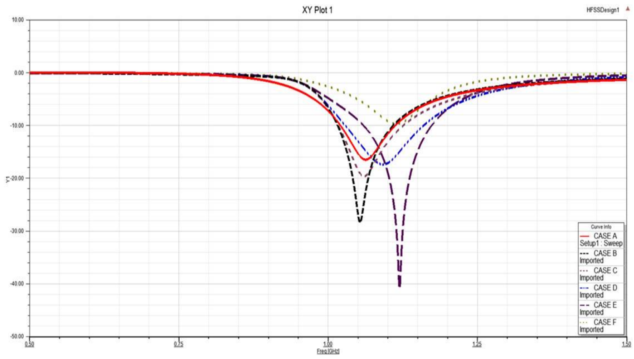


Fig. 3. Return loss for different case studied

Return loss in Case A for the proposed antenna is -16.47 dB with bandwidth of 92 MHz. The result of return loss and bandwidth for each case improved as more number of metal cylinder attached around the dipole antenna. In the earlier case where less number of metal cylinders attached, the result of beam direction does agree with the position of designated metal cylinder which is turned on. The direction of the beam is inconsistent when more metal cylinders are attached to the structure.

The exact value of maximum gain in the specific direction as each case studied is shown in Table II. The proposed dipole antenna gives an omnidirectional maximum radiation of 2.34 dBi at 1.06 GHz when no metal cylinders attached to the antenna. The maximum gain for each cases increase as the [illegible] working in more reconfigurable directions.

IV. Conclusion

A pattern reconfigurable half-wave antenna that can switch beam in numerous directions has been designed and tested using Ansys HFSS. By controlling pin diodes, the beam direction of the antenna can be switched accordingly. The design is working at low frequency with improved bandwidth. However, the design has a high profile structure which is not desirable in small communication devices. Future work will consider these issues and look into low profile wide bandwidth designs.

References

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